Abstract: Overcoming Genesis Mission Design Challenges

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Genesis is the fifth mission selected as part of NASA's Discovery Program. The objective of Genesis is to collect solar wind samples for a period of approximately two years while in a halo orbit about the Earth-Sun L1 point. At the end of this period, the spacecraft follows a free-return trajectory with the samples delivered to a specific recovery point on the Earth for subsequent analysis. This goal has never been attempted before and presents a formidable challenge for mission design, particularly with regard planning of various stochastic maneuvers.

To achieve a level of cost-effectiveness consistent with a low-cost Discovery-class mission, the Genesis spacecraft design was adapted to the maximum extent possible from designs used on earlier missions. Also, spin stabilization was chosen for attitude control, in lieu of three-axis stabilization, with neither reaction wheels nor accelerometers included, which precludes closed-loop control of propulsive maneuvers and decoupling of propulsive maneuvers and attitude control. Moreover, to minimize contamination risk to the samples collected, all thrusters were placed on the side opposite the sample collection canister.

A number of additional challenges have arisen as a result of emerging spacecraft design concerns and operational constraints. For example, the first trajectory correction maneuver after injection would likely need to be performed within 24 hours to avoid exorbitant delta-v cost. Successful execution entails minimizing the number and complexity of post-launch activities which could potentially trigger fault protection and result in lengthy recovery and delay of this critical maneuver. For this reason, only sun sensors will be available for attitude determination. However, accurate sun sensor readings in the presence of nutation require that maneuvers be avoided close to the sunward and anti-sunward directions. However, the first maneuver is largely an energy correction for injection and the velocity of the spacecraft is close to the sun line. Definition and analysis of approaches to overcoming this contradiction is one issue which will be discussed in the paper.

Another challenge involves design of station keeping maneuvers required to keep the spacecraft on the halo orbit during solar wind collection and positioned for eventual return to Earth. During this period, the primary science instrument, known as the Concentrator, collects Nitrogen and Oxygen ions onto a target via electrostatic grids. If the Concentrator is pointed more than 60 deg or so away from the sun when exposed to space, the grid becomes shaded introducing a large thermal gradient with respect to the container causing irreparable damage to the instrument. As a primary means of avoiding excessive turns away from the sun, all station keeping maneuvers need to be biased towards the sun. The paper will address the biasing strategy and analysis for this portion of the Genesis mission.

Finally, to attain the accuracy required for recovery with a high degree of robustness, some of the final maneuvers must be performed using a highly accurate mode involving spin changes. However, such accuracy necessitates larger maneuvers than would normally be required and maintenance of adequate power levels over an extended period. This entails use of yet another biasing strategy with considerable rehearsal and calibration activities prior to execution of these critical maneuvers. This paper will address analyses and issues dealing with the pre-entry leg of the Genesis mission.

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